Aerobraking: The Key to the Future of Affordable Mars Exploration

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Successfully aerobraking the Magellan spacecraft into a nearly circular orbit around Venus has enabled future interplanetary orbital missions to explore Mars in the era of low cost space missions. The reason that all foreseeable Mars orbital missions will use aerobraking is to lower the cost of the mission. For example, the Titan III/TOS launch vehicle for the Mars Observer mission cost about 350 million dollars. The Delta II 7925 launch vehicle for the Mars Global Surveyor mission will cost only 55 million dollars. The savings in the cost of the launch vehicle is more than the total cost of the Mars Global Surveyor mission including the spacecraft development, construction, launch, and operations. Using a smaller and therefore less expensive launch vehicle is possible because much less propellant has to be launched and captured into Mars orbit when aerobraking is used.

The Mars Global Surveyor spacecraft will launch in November of 1996 and be captured into a highly elliptical, 48 hour orbit around Mars with a 980 m/s propulsive maneuver in September of 1997. A four month aerobraking phase will remove another 1200 m/s from the orbit. Another pair of propulsive maneuvers totalling 75 m/s will be required to put the spacecraft into the final 2 pm, frozen, nearly circular Sun-synchronous mapping orbit. If the aerobraking phase were replaced by a series of propulsive maneuvers similar to those planned for Mars Observer, then the delta-V requirements would double, and the injected mass would have to increase by about 40°/0. Alternatively, if the launch vehicle is specified, then the dry mass of the spacecraft for an aerobraking mission is about 45°/0 larger than for an all propulsive mission.

Aerobraking at Mars is much more challenging than aerobraking at Venus. The gravity field of Mars has very large “bumps” such as the Tharsis region, and the perturbation on the spacecraft changes much more rapidly from orbit to orbit because Mars rotates much faster than Venus. Much less is known about the Martian atmospheric density and density fluctuations, so more margin must be included in the design. Aerobraking will occur during the peak dust storm season, so operations must be geared to respond to the large atmospheric density perturbations that will occur if a global dust storm erupts during the aerobraking phase.

The paper will show how all of the above issues have been accommodated by the design of the Mars Global Surveyor aerobraking phase.